On the stability of morphological parameters measurements with redshift

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Introduction

To understand how galaxies were formed and evolved, we need to measure their properties at different redshifts. Traditional morphological and structural parameters (e.g. Sérsic intensity, effective radius and index, concentration, asymmetry, Petrosian Radius, Gini coefficient) may be dependent on the image sampling, PSF and SNR. So in order to measure how the morphology of these objects evolve with time, we need to know how robust our measurements are at different redshifts. In this way, we used the FERENGI application to simulate the effect of observing the same galaxy at different redshifts. We applied the procedure to a sample of 100 galaxies from EFIGI database to artificially redshift local galaxies up to 1.5 Gpc ($z \approx 0.4$) and then used the MORFOMETRYKA package to measure several morphological and structural parameters. In this way we were able to check how the measurements behave as the spatial resolution and the SNR decreases. In the future, these measurements could be corrected for the effects of the given cosmological model.

Cosmological model

In order to understand how the redshift affects the measurements, we need a cosmological model that describe the universe expansion. In our case, the FRWL metric and the Friedmann's equation are the mathematical description necessary. Thus, the distance in the line of sight in this case is

$$D = D_H \int_0^z \frac{dz'}{(\Omega_M(1+z)^3 + \Omega_k(1+z)^2 + \Omega_\Lambda)^{\frac{1}{2}}}$$

where Ω_M, Ω_k and Ω_Λ are the energy density parameters, which is dependent from the cosmological model and D_H is the Hubble distance defined as

$$D_H = \frac{c}{H_0}$$

for a flat $\Lambda - CDM$ universe, $\Omega_k \approx 0$. In FERENGI, the numerical values for Ω_M and Ω_Λ are 0.3 and 0.7 respectively. H_0 is parameterized as follows

$$H_0 = \mathrm{h}\ (100\ \mathrm{km\ s^{-1}\ Mpc^{-1}})\ ,\ \mathrm{h} = 0.7$$

MORFOMETRYKA measurements

MORFOMETRYKA (Ferrari 2014) was used to measure the structural and morphological parameters from the galaxies. It takes each galaxy image, subtracts sky background, locates the object, measures the center, axes lengths and position angle; performs aperture photometry and fits a Sérsic law to the light profile (Sérsic 1968); measures Petrosian radius (Petrosian 1976), concentration, asymmetry, smoothness and Gini coefficient (Abraham 1994), (Conselice 2000) & (Lotz 2004). MORFOMETRYKA also presents a new asymmetry index **(A_3)** based on Spearman correlation coefficient.

EFIGI, our sample and FERENGI

We took 100 galaxies from EFIGI database and split them in two groups: **Elipticals & Lenticulars** (blue) and **Spirals** (orange). Galaxies with RC3 morph type of irregulars (red) are not accounted in the analysis. We applied the FERENGI package to the sample, it simulates the redshifting of an object to a given distance. It applies the correct cosmological corrections for size, surface brightness and bandpass shifting. In our case, we wrapped FERENGI's code to produce images of the selected galaxies to several redshifts in a given interval of 50 Mpc, from 0.1 Gpc to 1.5 Gpc.

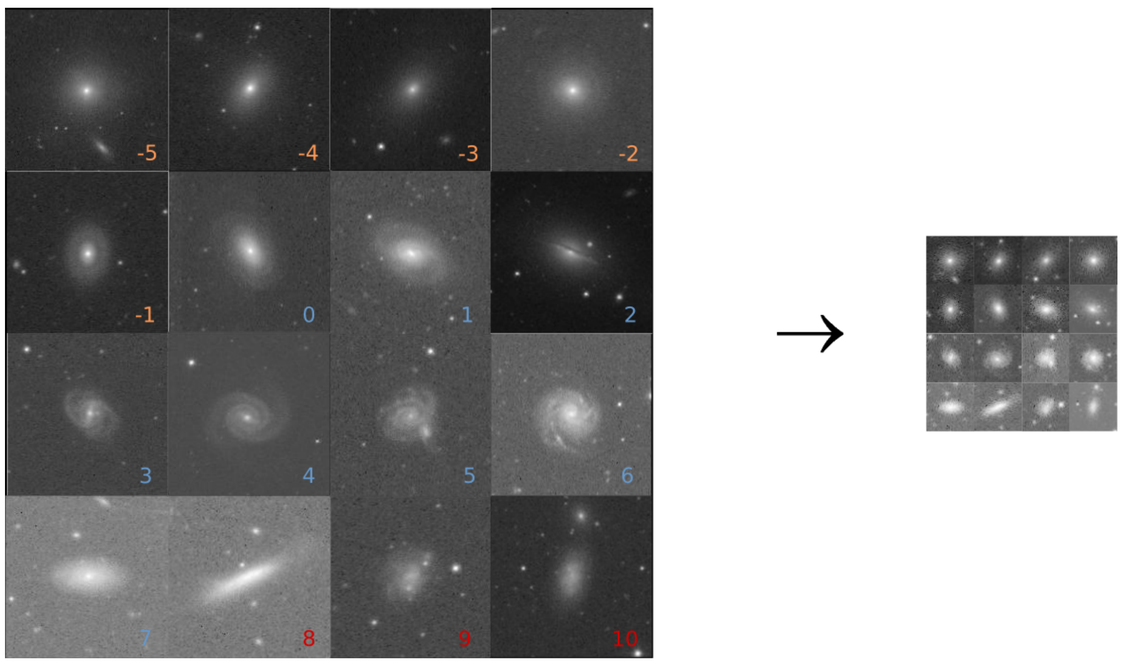

Figure: Examples of our sample in two steps of the simulation, z = 0.05 and z = 0.12 respectively. The images are in scale according to the resolution decreasement from the redshift increase. Numbers represents the sample's RC3 morphological types.

Acknowledgements

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References

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Measurements with the redshift

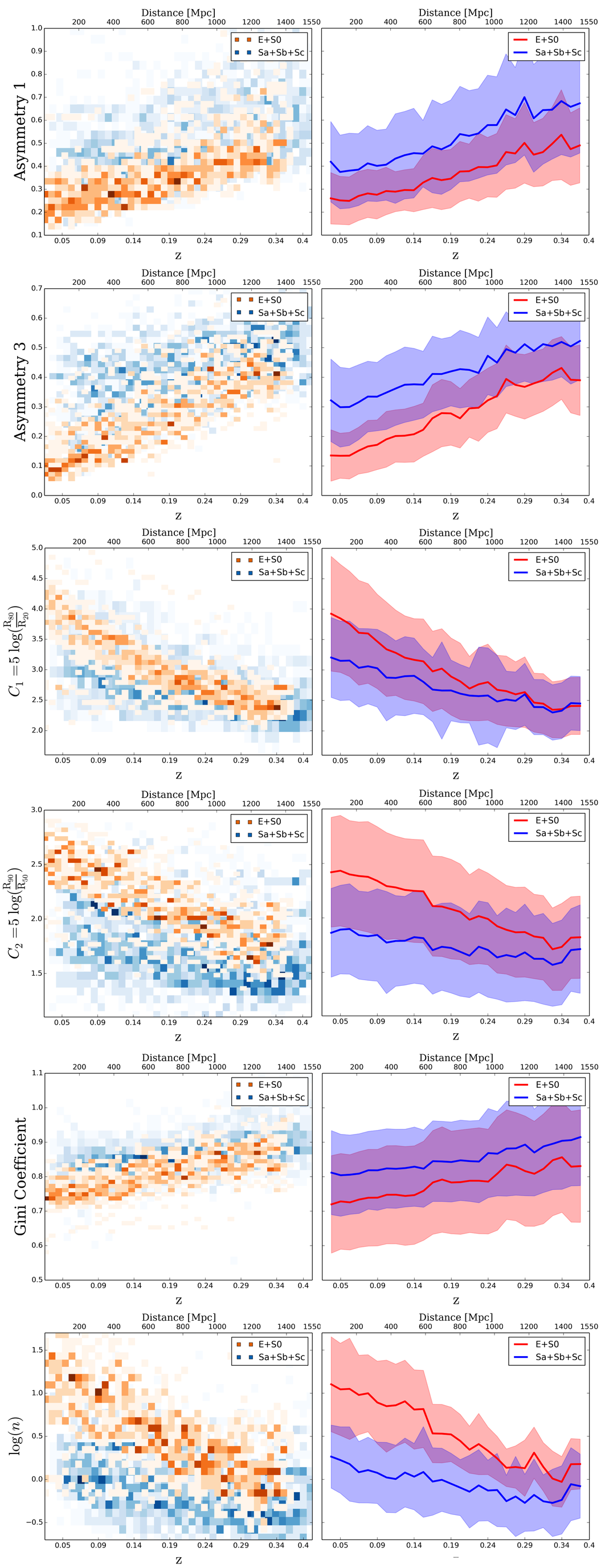

Figure: Density plots for the distribution of measurements (left) and mean values for the distribution represented by lines between $+1\ \sigma$ and $-1\ \sigma$. (right)

Conclusions & Future

- C_2 (outer) concentration **discriminates** better than C_1 (inner).
- **Image sampling** is crucial for morphometry measurements. General advice is $\mathrm{pixel\ size} < \frac{\mathrm{R_n}}{10}$
- With all EFIGI database galaxies we should be able to find corrections for the effects from the redshift in these structural paremeters.

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